

Available online at [www.sciencedirect.com](http://www.sciencedirect.com)**ScienceDirect**

Procedia Economics and Finance 25 (2015) 435 – 444

---

**Procedia**  
Economics and Finance

---

[www.elsevier.com/locate/procedia](http://www.elsevier.com/locate/procedia)

16th Annual Conference on Finance and Accounting, ACFA Prague 2015, 29th May 2015

## Segments of Money Market Yield Curves in a Dealers Model of Optimum Interest Rate Margin

Karel Brůna<sup>a\*</sup><sup>a</sup>*University of Economics, Prague; Department of Monetary Theory and Policy, W. Churchill Sq. 4, Prague 130 67, Czech Republic*

---

### Abstract

The paper deals with interest rate volatility interpretation in the dealer's model of optimal interest margin. It defines main sources of interest rate volatility and studies how specific source of volatility influences optimal interest margin. Special attention is focused on unexpected shock in liquidity of banking system, actual central bank's decision on targeted level of interest rate, long-term deviation of inflation and output from central bank's targeted values and potential impact of these factors on term premium instability. Sources of interest rates are discussed in term of bank's refinancing/reinvestment risk with an attempt to formalize interest rate volatility for further empirical research. The conclusion is that dealer's model of optimal interest margin is consistent with only permanent shocks to banking system liquidity and long-lasting central bank's surprises with its monetary policy that increase a level of refinancing/reinvestment risk faced up by banks. On the other hand it is not consistent with interest rate volatility caused by transitory liquidity shocks, expected current changes in central bank's targeted main policy rate and long run trends in main policy rate based on disinflation.

© 2015 The Authors. Published by Elsevier B.V. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

Peer-review under responsibility of University of Economics, Prague, Faculty of Finance and Accounting

*Keywords:* Interest margin; Interest rate volatility; Monetary policy

---

### 1. Introduction

A traditional approach to transmission through the bank channel relies on an assumption that lending and deposit rates follow the movements of central bank's main policy rate while especially the level of interest rate on credits

---

\* Corresponding author.

E-mail address: [bruna@vse.cz](mailto:bruna@vse.cz)

has restrictive and/or expansive effects. This approach does not usually have any microeconomic fundaments that necessarily lead to the finding that banks manage credit and deposit rates in the sense of interest margin. Without change in interest margin a change in the costs of financing through bank credits would cause the respective change in yields from bank deposits whereas the final effect of this change would be connected only with different structure between the recipients of bank credits (mainly the corporate sector) and creators of bank deposits (mainly the household sector) and/or with different marginal inclination to consumption/investments and interest elasticity of the function of savings supply and demand for credits.

Models of optimum interest margin of banks bring about an important approach to the mechanism of interest margin determination from the banks point of view that are in the imperfectly competitive banking market in the position of market makers determining individually the spread of deposit and lending rates. The use of these models by central bank for the analysis of monetary conditions allows understanding why under certain conditions the interest margin behaves in opposite direction to central bank's main policy rate. Nevertheless, models of optimum interest margin suffer from simplification when based on the existence of refinancing/reinvestment risk they automatically consider increasing/decreasing variability of interest rates on money market as the cause of an increase/decrease in the interest margin.

The objective of the present study is a theoretical analysis of main segments of money market yield curve in terms of sources of interest rate variability such as unexpected shock in the aggregated liquidity of the banking system, central bank's decision on a change in main policy rate, long-term deviation of inflation and output from the values targeted by central bank and related transmissions into the instability of term premium incl. their potential impacts on the interest margin of banks.

## 2. An Interest Rate Risk on Money Market in a Dealer's Model of Optimum Interest Margin

The pioneer paper of Ho and Saunders (1981) presented a classical approach to the management of interest margin. The authors defined the basic determinants of interest margin as imperfect competition on the bank market, risk aversion of a bank, volatility of interest rates and the size of demand for credits and/or supply of deposits. The model of the optimal interest margin was subsequently developed in the studies of McShane and Sharpe (1985), Allen (1988), Angbazo (1996), Saunder and Schumacher (2000), and Maudos and Fernandez de Guevara (2004) while the original approach was enlarged by the factors such as credit risk, level of operating costs and influence of regulatory measures. The model does not involve a scenario when the banking sector undergoes a dramatic change in the institutional structure and a jump change in the behaviour of banks and their clients like in transition economies that will influence the stability of the interest rate transmission mechanism of monetary policy at the stage of transmission of changes in market interest rates into client interest rates.

The model of the optimal interest margin assumes that on the side of the supply of savings the bank is taken as a passive recipient of deposits, on the side of the demand for savings the model leaves a space for a scenario that the bank will restrain the supply of credits. The bank accepts deposits and grants credits the maturity of which goes beyond the horizon of a short period the bank takes into account for determination of an optimal interest margin. The bank grants credits and accepts deposits at fixed "long-term" lending and deposit interest rate  $IR_L$  and  $IR_D$  whose level is based on a mark-up to the actual market interest rate  $IR_M$ .

According the model supply of deposits and demand for credits are random variables. The probability of granting a loan and receiving a deposit is simulated as Poisson's process, and it is a decreasing function of the size of the margin on the loan and deposit market  $a$  and  $b$ . The exposure of a bank to interest risk means that the supply of deposits may be realised at a different time moment than the demand for loans. In this case the bank gets into a speculative position on the money market when it is exposed to refinancing or reinvestment risk due to the fluctuation of interest rates. The interest margin  $a + b$  is considered as the bank's earnings for the risk of an unexpected future change in interest rate and consequent loss of the bank's net worth in relation to the potentially unbalanced position between the volumes of new loans ( $L$ ) and deposits ( $D$ ). The bank decides on the size of interest margin to maximise the expected net worth ( $W^e$ ) at the end of the period for which the rates  $IR_L$  and  $IR_D$  were fixed. This aim is achieved at the moment when margin  $a$  and  $b$  are fixed so as to minimise the risk of imbalance between the supply of deposits and demand for credits. The optimal interest margin is given by this equation:

$$a + b = \frac{1}{2} \left( \frac{\alpha_D}{\beta_D} + \frac{\alpha_L}{\beta_L} \right) + \frac{1}{2} \left( \frac{C(L)}{L} + \frac{C(D)}{D} \right) - \frac{1}{4} \frac{U''(W^e)}{U'(W^e)} \left[ (L + 2L_0)\sigma_L^2 + (L + D)\sigma_M^2 + 2(M_0 - L)\sigma_{LM} \right] \quad (1)$$

where	$\alpha_L$ and $\alpha_D$	=	autonomous demand for credits and supply of deposits
	$\beta_L$ and $\beta_D$	=	elasticity of demand for credits and supply of deposits in relation to the change in margin $a$ and $b$
	$C(L)$ and $C(D)$	=	operating costs of the granting of new loans and/or reception of new deposits
	$\frac{U''(W^e)}{U'(W^e)}$	=	bank's risk aversion
	$L_0$ and $M_0$	=	volume of credits and bank's net position on the money market at the moment of decision-making on the size of interest margin
	$\sigma_L^2$ , $\sigma_M^2$ , $\sigma_{LM}$	=	credit risk, interest risk, covariance of credit and interest risk

### 3. Structure of interest rate variability sources and their formalization to main segments of money market yield curve

It is assumed that agents in the money market compare the magnitude of quoted  $n$ -day interest rate at a time moment  $t$  with the expected future development of O/N interest rates in  $n$ -day horizon while their preferences make them demand an increasing term premium with the longer period of maturity. In an aggregated form resultant equilibrium in the money market can be expressed as the equilibrium of a risk averse speculator who, based on actually available information ( $\Omega_t$ ), quotes the actual  $n$ -day interest rate ( $IR_t^n$ ) as the sum of the expected average level of O/N rates in the period of  $t$  to  $t+k$  and term premium ( $\rho_t^n$ ):

$$IR_t^n = \frac{1}{n} \sum_{k=0}^{n-1} IR_{t+k}^{O/N,e} | \Omega_t + \rho_t^n \quad (2)$$

It is also assumed that the central bank uses  $s$ -day interest rate ( $IR_{CB,t}^s$ ) in the position of main policy rate while the maturity of this rate maximally equals the maturity of ultra-short rates (i.e.  $s \leq n$ ). From the aspect of the banking system liquidity management it is also necessary to consider the duration of the period within which banks are obliged to hold a certain volume of minimum required reserves with central bank. It is assumed that the duration of so called maintenance period  $r$  is longer or maximally equals the maturity of main policy rate (i.e.  $s \leq r$ ) while it holds good that  $r$  is usually the whole multiple of  $s$  so that the end of the holding period would be identical with the maturity of a tender for liquidity supply/withdrawal at  $s$ -day main policy rate.

Taking into account an optimum reaction of banks to the dynamics of interest rates in the money market basic sources of interest rate variability in the money market can be defined: unexpected shock in aggregated liquidity of the banking system, central bank's decision on a change in main policy rate, long-term deviation of inflation and output from the values targeted by central bank and the related potential transmission into the instability of term premium.

#### 3.1. Unexpected shock in aggregated liquidity of the banking system and variability in O/N interest rates (Segment 1)

An unexpected shock in aggregated liquidity of the banking system is caused by a difference between the level of demand for liquidity by the banking system as expected by central bank and its actual level for a given trade day. The shock defined in this way assumes that the supply of central bank's liquidity is basically fully adapted to the so called autonomous factors of demand for liquidity, i.e. the unexpected shock in the banking system liquidity corresponds to a difference between the expected and actual volume of autonomous factors. Quantification of this shock is based on the balance sheet approach to liquidity resources and use in the banking system. The side of

liquidity resources ( $L_Z$ ) fully corresponds to the conception of liquidity supply by central bank ( $L_S$ ) and it may be identified with the main items on the assets side of central bank's balance sheet, i.e. foreign exchange reserves (DR), credit facilities (U), securities held on outright ( $CP_{OUTRIGHT}$ ) and reverse repo ( $CP_{REVREPO}$ ) basis, securities held as collateral for lending facility ( $CP_{ZF}$ ) and other assets ( $OST_{AKTIVA}$ ). Liquidity use ( $L_U$ ) corresponds to the main items on the assets side of central bank's balance sheet as minimum reserve requirements (PMR), excess reserves (DoR), currency in circulation (O), government deposits ( $D_{VL}$ ), liquidity deposited with central bank through outright operations ( $D_{OUTRIGHT}$ ), repo operations ( $D_{REPO}$ ) and deposit facility ( $D_{DF}$ ) and as other liabilities ( $OST_{PASIVA}$ ). Liquidity use involves demand of banks for liquidity ( $L_D$ ) and liquidity sterilization. These basic relations hold good:

$$L_Z = L_S = DR + U + CP_{OUTRIGHT} + CP_{REVREPO} + CP_{ZF} + OST_{AKTIVA} \quad (3)$$

$$L_U = L_D + \text{liquidity sterilization} = PMR + DoR + O + D_{VL} + OST_{PASIVA} + D_{OUTRIGHT} + D_{REPO} + D_{DF} \quad (4)$$

$$L_D = PMR + DoR + O + D_{VL} \quad (5)$$

$$\text{liquidity sterilization} = D_{OUTRIGHT} + D_{REPO} + D_{DF} \quad (6)$$

The definition of unexpected shock in the banking system liquidity takes into account daily changes in relations between resources of the banking system liquidity and demand of banks for this liquidity, i.e. it depicts a daily change in the short-term net liquid position of the banking system vis-à-vis the central bank that is reflected in a change in the volume of sterilized liquidity:

$$\Delta \text{liquidity sterilization} = (\Delta DR + \Delta U + \Delta CP_{OUTRIGHT} + \Delta CP_{REVREPO} + \Delta CP_{ZF} + \Delta OST_{AKTIVA}) - (\Delta PMR + \Delta DoR + \Delta O + \Delta D_{VL} + \Delta OST_{PASIVA}) = \Delta D_{OUTRIGHT} + \Delta D_{REPO} + \Delta D_{DF} \quad (7)$$

Standard practice of liquidity management in the banking system relies on the fact that liquidity supply by central bank is endogenous and so it is adapted to changes in the demand of banks for liquidity. However, within a tender for liquidity supply/withdrawal the equilibrium between liquidity resources and demand for liquidity cannot be expected automatically because central banks do not have an exact notion of the volume of liquidity demanded by banks within this tender and of the extent of subsequent autonomous changes in liquidity during the day, and the endogeneity of central bank's liquidity supply may be different from particular components of the demand for liquidity.

In general, banks demand liquidity in order to hold a certain volume of reserves that may be larger or smaller than the actual minimum reserve requirement and/or their demand for excess reserves may be both positive and negative, depending on how advantageous for bank financing the liquidity resources from central bank are on a given day in comparison with resources available in the interbank market. On the other hand, the banking system liquidity is affected during the day by unexpected changes in autonomous factors such as changes in currency in circulation and government deposits that influence the volume of available liquidity in the market in the meantime from the termination of a tender for liquidity supply/withdrawal to the moment when banks can use an automatic facility. Last but not least, it is to note that while the central bank is ready to fully absorb expected movements of the volume of currency in circulation and government deposits by liquidity supply/withdrawal, the flexibility vis-à-vis the bank demand for excess reserves may be significantly lower and/or can react only under specific circumstances of increased demand for liquidity (end of the holding period, freezing of the interbank market).

Based on these assumptions we define unexpected shock in the banking system liquidity as the situation of an unexpected change in the volume of sterilized liquidity caused on the one hand by central bank's error in the estimation of the magnitude of a change in bank demand for liquidity (both within the tender for liquidity supply/withdrawal and further during the day) and on the other hand by the surprise of banks resulting from central bank's targeted default to accommodate to an in advance unknown part of the change in their demand for excess reserves. To define central bank's error it is necessary to exclude the situation when such an error is influenced by the fact that the central bank does not accommodate to changes in demand for excess reserves (i.e. let us assume the stability of excess reserves  $DoR = k$ , i.e.  $\Delta DoR = 0$ ). Then it is possible to write:

$$\Delta L_{S, \Delta DoR=0} - \Delta L_{D, \Delta DoR=0} = \Delta L_{S, \Delta DoR=0, \text{non expD}} - \Delta L_{\text{expD}, \Delta DoR=0} + \Delta L_{\text{expD}, \Delta DoR=0} - \Delta L_{D, \Delta DoR=0} \quad (8)$$

$$\Delta L_{S, \Delta DoR=0, \text{expD}} - \Delta L_{\text{expD}, \Delta DoR=0} = 0 \quad (9)$$

where  $\frac{\Delta L^{S, \Delta DoR=0, \text{expD}}}{\Delta L^{\text{expD}, \Delta DoR=0}}$  - difference between the change in liquidity supply (for the case when the liquidity supply does not accommodate to changes in the volume of currency in circulation and movements on the government account) and expected change in demand for liquidity corresponding to changes in autonomous factors anticipated by central bank (in the case of the considered full endogeneity of liquidity supply we assume that  $\Delta L^{S, \Delta DoR=0, \text{non expD}} - \Delta L^{\text{expD}, \Delta DoR=0} = 0$ )

$\frac{\Delta L^{\text{expD}, \Delta DoR=0}}{\Delta L^{D, \Delta DoR=0}}$  - difference between the expected change in demand for liquidity resulting from the expected change in the volume of autonomous factors and the actual demand of banks for liquidity

Assuming that the central bank fully covers expected changes in demand for liquidity by virtue of changes in the issuance of currency in circulation and changes in the volume of government deposits, central bank's error in the estimation of changes in the bank demand for liquidity can be defined as follows:

$$\Delta L^{S, \Delta DoR=0, \text{expD}} - \Delta L^{D, \Delta DoR=0} = (\Delta PMR^{\text{exp}} + \Delta O^{\text{exp}} + \Delta D_{VL}^{\text{exp}} + \Delta OST_{PASIVA}^{\text{exp}}) - (\Delta PMR + \Delta O + \Delta D_{VL} + \Delta OST_{PASIVA}) \quad (10)$$

The surprise of banks caused by a default to accommodate to their changing demand for excess reserves is defined as follows (it is assumed that the other components of the demand function are correctly predicted by central bank, i.e. for  $\Delta L^{S, \Delta DoR=0} = \Delta L^{D, \Delta DoR=0}$ ):

$$\Delta L^{S, \Delta DoR=0} - \Delta L^{D, \Delta DoR \neq 0} = (\Delta PMR^{\text{exp}} + \Delta O^{\text{exp}} + \Delta D_{VL}^{\text{exp}} + \Delta OST_{PASIVA}^{\text{exp}}) - (\Delta PMR + \Delta O + \Delta DoR + \Delta D_{VL} + \Delta OST_{PASIVA}) = -\Delta DoR \quad (11)$$

Hence unexpected shock is the sum of both components:

$$\Delta L^{S, \Delta DoR=0, \text{expD}} - \Delta L^{D, \Delta DoR=0} + \Delta L^{S, \Delta DoR=0} - \Delta L^{D, \Delta DoR \neq 0} = \Delta L^{S, \Delta DoR=0, \text{expD}} - \Delta L^{D, \Delta DoR \neq 0} \quad (12)$$

As for O/N interest rates, it is to consider that O/N interest rates sensitively reflect changes in the volume of banking system liquidity. Therefore it is possible to write that O/N interest rate and/or its variability is a (not in greater detail specified) function of unexpected shock in the volume of banking system liquidity and/or variability of this shock:

$$\text{varIR}^{O/N} = f(\text{var}(\Delta L^{S, \Delta DoR=0, \text{expD}} - \Delta L^{D, \Delta DoR \neq 0})) \quad (13)$$

With the endogeneity of liquidity supply the variability of O/N interest rates is influenced both by central bank's ability to anticipate the variability of bank demand for liquidity and by the instability of bank demand for excess reserves. As for the impact on interest margin, it is necessary to distinguish errors in the estimation of variability of bank demand for liquidity that are of transitory nature because these are efficiently eliminated within the maintenance period because the prediction mechanism of bank demand for liquidity contains the *ex post* analysis of liquidity resources and use for the entire holding period, from errors in the estimation of variability of permanent and/or longer-lasting nature that indicate either inherent problems in the model apparatus of prediction of bank demand for liquidity or changes in the formation of bank demand for liquidity as such. In the estimation errors of transitory nature no significant impact on interest margin can be expected because the transitorily increased variability of O/N interest rates is not transmitted along the entire yield curve in the money market. On the contrary, in the errors of permanent nature an increase in the variability of O/N rates inevitably indicates the impairment of conditions of (re)financing in the money market and so it may be reflected in an increase in term premium even in a very short segment of the money market and/or in their deviation from central bank's main policy rate with subsequent transmission into an increase in the interest margin of banks.

### 3.2. Central bank's decision on a change in main policy rate, transmission of variability of O/N interest rates and surprise in main policy rate variability (Segment 2)

A crucial problem of interest rate variability is the transmission of O/N interest rate variability along the yield curve. At the short end of the yield curve interest rate variability is influenced by central banks that stabilize the average level of O/N interest rates through the balancing of resources and use of the banking system liquidity to the proximity of  $x$ -week effective rate from monetary operations for liquidity supply/withdrawal. For the reason of monetary policy transparency the effective rate is maintained in the proximity of announced main policy rate. Hence the question is to what extent the actual change in announced main policy rate can influence O/N interest rate variability on the one hand, and on the other hand what its influence on the transmission of O/N interest rate variability along the yield curve will be like.

In the former case the actual change in main policy rate represents a purely transitory source of an increase in O/N interest rate variability when the change in main policy rate alters the level of the price at which equilibrium between the resources and the use of the banking system liquidity is maintained through the above described mechanism. The expectation of a change in main policy rate within the holding period may lead to time-limited changes in the variability of demand for excess reserves because the banks optimize, by means of intertemporal substitution, total costs of the liquidity holding by virtue of minimum required reserves and increase (decrease) demand for liquidity for a short time at the expected increase (decrease) in main policy rate (see Brůna 2007). If the increase in the variability of demand for liquidity is not absorbed in an adequate way by adaptation on the liquidity supply side, such a situation leads to a transitory increase in variability of O/N interest rates. However, with respect to the management of interest margin of banks this event does not have an immediate influence either on average costs or on the risk component of bank financing in the money market and should not have an influence on the spread of lending and deposit rates.

Concerning the transmission of O/N interest rates, Ayuso, Haldane and Restov (1997) demonstrated that under normal circumstances unconditional variability of interest rates in the money market has the shape of an asymmetric U curve when O/N interest rate variability is relatively high and potentially unstable, interest rate variability at the short end of the yield curve is relatively low and stable while it basically corresponds to the variability of actual main policy rate, and variability at the longer end of the yield curve is gradually increasing while the stability of such variability may decrease as a consequence of divergence of financial market expectations from the actual policy of changes in main policy rate.

However, the influence of O/N interest rate variability may be different in connection with a change in main policy rate if these changes are combined with uncertainty caused by this change. As stated by Alonso and Blanco (2005), such transmission may occur either shortly before the central bank decides on the setting of main policy rate or if the central bank takes a surprising decision when the agents in the money market are facing heterogeneous expectations about the extent and direction of main policy rate movement and its future trajectory and/or about the reasons and logic behind central bank's behaviour. Consequently, it results in an immediate increase in the variability of actual and future expected ultra-short interest rates and in the variability of term premium, and interest rates both at the short and at the long end of the yield curve are influenced parallelly.

Variability transmission along the yield curve in the context of central bank's actual decision-making is basically a problem to what extent the banks understand central bank's decision-making mechanism. In the framework of the inflation targeting mechanism this mechanism can be described in a standard way by central bank's reaction function:

$$IR_{CB,t}^{OPTIM} = IR_{CB}^{EQ} + \beta_t (\pi_{t+k}^e - \pi_{t+k}^{TARGET}) + \gamma_t (y_{t+k}^e - y_{t+k}^*) \quad (14)$$

$$IR_{CB,t}^{TARGET} = (1 - \rho) IR_{CB,t}^{OPTIM} + \rho IR_{CB,t-1}^{TARGET} + w_t \quad (15)$$

where  $IR_{CB,t}^{OPTIM}$  = model optimum main policy rate of central bank  
 $IR_{CB}^{EQ}$  = main policy rate corresponding to the zero difference of expected inflation ( $\pi_{t+i}^e$ ) from inflation target ( $\pi_{t+i}^{TARGET}$ ) and/or of expected



$$\begin{array}{ll}
& \text{economic growth } (y_{t+i}^e) \text{ from potential output } (y_{t+i}^*) \\
\beta_t \text{ and } \gamma_t & = \text{convolution of parameters describing central bank's preferences to the} \\
& \text{inflation and business cycle and structural characteristics of the economy} \\
& \text{(see Svensson, 1996; Favero and Rovelli, 2000).} \\
IR_{CB,t}^{TARGET} & \text{announced main policy rate} \\
w_t & \text{other factors}
\end{array}$$

From the aspect of banks the situation when the banks correctly interpret central bank's policy and when it is not to expect that a change in announced main policy rate is the reason for a change in their interest margin should be distinguished from the situation when central bank takes systematically surprising decisions. Surprise can be defined as a difference between the variability of announced main policy rate and the variability of the level of announced main policy rate expected by banks:

$$\begin{aligned}
\text{var } IR_{CB,t}^{TARGET} - \text{var } IR_{CB,t}^{TARGET,e} &= \left[ (1-\rho)^2 \text{var } IR_{CB,t}^{OPTIM} - (1-\rho^e)^2 \text{var } IR_{CB,t}^{OPTIM,e} \right] + \\
&+ (\rho^2 - \rho^{e,2}) \text{var } IR_{CB,t-1}^{TARGET} + (\text{var } w_t - \text{var } w_t^e) + \\
&+ \left[ 2(1-\rho)\rho \text{cov}(IR_{CB,t}^{OPTIM}, IR_{CB,t-1}^{TARGET}) - 2(1-\rho^e)\rho^e \text{cov}(IR_{CB,t}^{OPTIM,e}, IR_{CB,t-1}^{TARGET}) \right] + \\
&+ \left[ 2(1-\rho) \text{cov}(IR_{CB,t}^{OPTIM}, w_t) - 2(1-\rho^e) \text{cov}(IR_{CB,t}^{OPTIM,e}, w_t^e) \right] + \\
&+ \left[ 2\rho \text{cov}(IR_{CB,t-1}^{TARGET}, w_t) - 2\rho^e \text{cov}(IR_{CB,t-1}^{TARGET}, w_t^e) \right]
\end{aligned} \quad (16)$$

Sources of differences between actual and expected variability in announced main policy rate can be seen in a) different database of the model by means of which the optimum reaction of main policy rate can be derived that results from information asymmetry between central bank and other banks within which the central bank has a wider set of information relevant for monetary policy decisions; b) in a different method of interpretation of the otherwise identical data that is based, on the one hand, on certain unambiguity of information coming from different sectors of the economy and, on the other hand, is a result of the more professional analysis of this data by central banks thanks to central bank's human resources; c) in the dynamics of structural parameters of the model reflecting the variable structure of the economy and behaviour of economic agents; d) in the instability of the factor of inertia in central bank's decision-making when some inconsistency in central bank's aggressiveness in reaction to the business and inflation cycle may be manifest and e) in the erroneous evaluation of factors beyond the traditional prediction model of central bank that however influence the setting of announced main policy rate, e.g. a concern to maintain the stability of the financial system in reaction to financial crisis, bursting of price bubbles in stock or real estate markets, bank credit crunch or liquidity problems of the banking system, or factors resulting from the restriction of the fixed exchange rate regime, from inelasticities in the labour market or from the existence of systematic errors in economic growth estimations.

In all the above-mentioned cases a surprise in the variability of announced main policy rate causes an increase in the variability of O/N interest rates that is transmitted along the yield curve both in the short and in the long segment of this curve. From the aspect of interest margin management the particular causes of this surprise are a significant source of misunderstanding the central bank that exactly correspond with the comprehension of an increase in interest rate variability as a source of higher risk undertaken by banks. Under these circumstances it is comprehensible that the banks react sensitively to changes in interest rate variability by adapting their interest margin because they efficiently reduce in this way the negative impact of an unexpected change in the variability of main policy rate of banks.

### 3.3. Long-term difference of inflation/output and their targets and the conflict between variability of actual and expected main policy rate and dynamics of economic fundamentals (Segment 3)

In general, the variability of  $n$ -month interest rate can be understood as the function of variability of expected optimum main policy rate, variability of expected announced main policy rate, variability of the other factors in

central bank's reaction function and variability of term premium incl. the influence of respective covariances (Brůna 2009):

$$\begin{aligned} \text{var IR}_t^n = \frac{1}{n^2} & \left[ (1-\rho)^2 \text{var} \sum_{j=0}^{n-1} \text{IR}_{\text{CB},t+j}^{\text{OPTIM},e} + \rho^2 \text{var} \sum_{j=0}^{n-1} \text{IR}_{\text{CB},t+j-1}^{\text{TARGET},e} + \right. \\ & + \text{var} \sum_{j=0}^{n-1} w_{t+j}^e + 2(1-\rho)\rho \text{cov} \left( \sum_{j=0}^{n-1} \text{IR}_{\text{CB},t+j}^{\text{OPTIM},e}, \sum_{j=0}^{n-1} \text{IR}_{\text{CB},t+j-1}^{\text{TARGET},e} \right) + \\ & + 2(1-\rho) \text{cov} \left( \sum_{j=0}^{n-1} \text{IR}_{\text{CB},t+j}^{\text{OPTIM},e}, \sum_{j=0}^{n-1} w_{t+j}^e \right) + \\ & \left. + 2\rho \text{cov} \left( \sum_{j=0}^{n-1} \text{IR}_{\text{CB},t+j-1}^{\text{TARGET},e}, \sum_{j=0}^{n-1} w_{t+j}^e \right) \right] + \\ & + \text{var } \rho_t^n + \frac{2}{n} \text{cov} \left\{ \left[ (1-\rho) \sum_{j=0}^{n-1} \text{IR}_{\text{CB},t+j}^{\text{OPTIM},e} + \rho \sum_{j=0}^{n-1} \text{IR}_{\text{CB},t+j-1}^{\text{TARGET},e} + \sum_{j=0}^{n-1} w_{t+j}^e \right], \rho_t^n \right\} \end{aligned} \quad (17)$$

while it holds good that:

$$\begin{aligned} \text{var} \sum_{j=0}^{n-1} \text{IR}_{\text{CB},t+j}^{\text{OPTIM},e} = \text{var} \sum_{j=0}^{n-1} \beta_{t+j} (\pi_{t+k+j}^{e,t+j} - \pi_{t+k+j}^{\text{TARGET}}) + \text{var} \sum_{j=0}^{n-1} \gamma_{t+j} (y_{t+k+j}^{e,t+j} - y_{t+k+j}^*) + \\ + 2 \text{cov} \left( \sum_{j=0}^{n-1} \beta_{t+j} (\pi_{t+k+j}^{e,t+j} - \pi_{t+k+j}^{\text{TARGET}}), \sum_{j=0}^{n-1} \gamma_{t+j} (y_{t+k+j}^{e,t+j} - y_{t+k+j}^*) \right) \end{aligned} \quad (18)$$

A difference between the variability of main policy rate and variability of interest rates in the money market generally consists in the varying resoluteness of central bank how it reacts through the trajectory of changes in main policy rate to deviations of inflation from the inflation target and to the related fluctuations in economic growth (Mehra, 1996). This is the reason why the reaction of interest rates to adopted monetary policy measures is not always well predictable. As stated e.g. by Rolley and Sellon (1995), the intensity of interest rate reactions to changes in main policy rate is strongly conditioned by the actual phase of the business cycle that significantly influences investors' expectations about the future development of inflation and economic growth and that predetermines whether the actual change in main policy rate is taken as a trend change in main policy rate which has potentially ambitions to act as a tool of monetary restriction or expansion, or as a transitory movement within the policy of the fine-tuning of main policy rate.

It is inevitably connected with the fact that the sensitivity how the central bank perceives changes in actual and expected inflation and economic growth is not identical within the business cycle. While in the period when inflation is in line with targeted values or the inflation target is moderately undershot, central banks are willing to support economic growth to some extent (i.e. the real level of main policy rate follows the business cycle), at the moment when inflation is above the inflation target for a long time and the economy shows the features of overheating at the same time, their sensitivity to economic growth rapidly decreases (i.e. the real level of main policy rate acts against the business cycle). The consistency of central bank's expected monetary policy measures with investors' projections of future inflation and economic growth may be based on the variable pace of central bank's transition between the particular phases of monetary restriction/expansion and different intensity of related changes in main policy rate.

The long-term difference of inflation and economic growth from targeted values creates opportunity for trend adaptation of main policy rate. The actual changes in main policy rate should be evaluated as part of the longer-term trend resulting from the need of adaptation, initiated by central bank, of the dynamics of processes in the economy to the values corresponding to long-term equilibrium. The related transmission of O/N interest rate variability into interest rates with longer maturity has a character of false causality ensuing from effect of the third factor, which is the variability of policy rate varying in the long run.

Even though equations (17) and (18) explicitly show that the trend movement of main policy rate supported by



economic fundamentals (i.e. an increase in variability of optimum main policy rate) causes an automatic increase in interest rate variability, a specific situation can be identified theoretically when the variability of interest rates at the long end of the yield curve may reflect – as the period of considered dynamics of inflation and economic growth partly reaches the horizon of monetary policy transmission – the assumed macroeconomic effects of monetary policy, which allows achieving the low variability of longer-term interest rates even in the situation of increased instability of interest rates with very short maturity. However, the probability that this case will be a description of the current dynamics of interest rates is relatively low because it is based on a strong assumption of central bank's absolute credibility, perfect prediction capacities of central bank and absolute efficiency of monetary policy. The deviation from these assumptions, while the low variability of longer-term interest rates is maintained, would inevitably cause the high variability of expected real interest rates that would be retroactively projected into the increased variability of business cycle through consumption and investment instability. Hence in reality central bank's monetary policy measures are usually confronted with the actual and expected dynamics of inflation and business cycle and so they are connected with increased variability of interest rates in the money market.

If for the trend movement of main policy rate we consider as realistic the scenario when the central bank's policy does not systematically surprise banks, then crucial problems from the aspect of interest rate variability are the rapidity of effects of changes in the intensity of monetary restriction in the inflation and output gap and the duration of increased variability of main policy rate necessary to achieve targeted values. It is basically the intensity of the reaction of an economic system to central bank's measures that is not known in advance in spite of the existence of an updated structural model of the economy. The problem is that any model works with a certain level of parametric uncertainty (Sack, 1998) that can be considered, *inter alia*, as a function of changes in the behaviour of economic agents who sensitively react to the intensity of monetary restriction. So it is not possible to explicitly anticipate the reactions of targeted fundamental variables because the actual shape of the structural model is always a result of the policy adopted by central bank.

The influence of changes in interest rate variability with longer maturity on interest margin is complicated by the fact that the banks use the segment of ultra-short maturities for their financing in the money market and that in the framework of financing through customer deposits deposit interest rates are closely linked with interest rates at the short end of the yield curve. In this case the variability of longer-term interest rates is not immediately reflected in the extent of refinancing/reinvestment risk. If the movements of main policy rate underlying the variability of longer-term interest rates acquire a trend character, the related increased variability of short-term interest rates need not significantly complicate the conditions of bank financing by the impact on an increase in the bank interest margin if these changes are correctly interpreted by banks and hence expected. But impacts on interest margin can be expected when the variability of term premium in longer-term interest rates and the variability of main policy rate are linked with each other due to the impaired credibility of central bank, uncertainty about monetary policy effects or uncertainty about the intensity of monetary restriction.

#### 4. Conclusions

The analysis of different interpretation of interest rate variability in the money market in the framework of a dealer's model of interest margin is a contribution to the discussion about the efficiency of central bank's policy. Unlike the traditional method that takes into account the existence of refinancing and/or reinvestment risk in the assessment of bank credits, our approach is aimed at differentiation of the sources of interest rate variability, their risk assessment in the framework of the financial management of banks and evaluation of their potential influence on interest margin. Our approach reveals four crucial sources of interest rate variability in the money market – unexpected shock in the aggregated liquidity of the banking system, central bank's decision on a change in main policy rate, long-term deviation of inflation and output from the values targeted by central bank and potential transmission of these factors into the instability of term premium. Unexpected shock in the volume of the banking system liquidity is connected with central bank's capacity to anticipate the variability of bank demand for liquidity and with the instability of demand for excess reserves. The impact on interest margin can be assumed only if this shock is of permanent nature reflecting problems in the apparatus of prediction of demand for liquidity or incomplete endogeneity of the liquidity supply by central bank. The impact of central bank's decision on a change in main policy rate on interest rate variability is connected with a systematic surprise for banks consisting in a difference between the actual variability of main policy rate and its variability expected by banks.

The long-term difference of inflation and economic growth from targeted values causes the trend adaptation of main policy rate that however does not have a direct relation with the variability of interest rates in the money market with longer maturity. In this relation it is basically a problem of the consistency of expected monetary policy measures and investors' ideas about the future dynamics of inflation and economic growth that results from the varying pace of transition between the particular phases of monetary restriction/expansion within the business and inflation cycle, from the unclear rapidity of impacts of the intensity of monetary restriction in the inflation and output gap and from the unknown duration of increased variability in main policy rate necessary to reach targeted values. The transmission of interest margin is complicated by the limited use of money market segments with longer maturity for bank financing and by the close relationship of credit and deposit rates with the dynamics of interest rates with short maturity. If the banks interpret the above-mentioned sources of interest rate variability as an increase in uncertainty, interest rate variability at the short and at the longer end of the yield curve is influenced by a positive correlation between the effects of these sources and term premium variability. The influence of interest rate variability is consistent with the conception of refinancing and/or reinvestment risk but its impact on interest margin is limited by the fact that the significance of term premium for interest rate variability becomes manifest in the segment of longer maturities.

### Acknowledgements

The article was supported by Internal Grant Agency of the University of Economics, Prague under a research project no. F1/5/2014 "Financial and Economic Cycles" and by Institutional Support of Research at University of Economics, Prague under a project no. IP 1000040

### References

- Angbazo, L. 1997: Commercial Bank Net Interest Margins, Default Risk, Interest-rate Risk, and Off-balance Sheet Banking. *Journal of Banking and Finance*. 1997, vol. 21, no. 1, 55-87.
- Berlin, M. - Mester, L. J. 1998: Deposits and Relationship Lending [Working Paper No. 98-22]. Philadelphia: Federal Reserve Bank of Philadelphia, November 1998.
- Brůna, K. 2005: Mechanismus stabilizace ultrakrátkých úrokových sazeb prostřednictvím repo operací České národní banky. *Politická ekonomie*. 2005, vol. LII, no. 4, 459-476.
- Brůna, K. 2007: Měnová politika, změny trendové inflace a nestabilita úrokových relací: analýza dynamiky dlouhodobých úrokových sazeb v kontextu změn repo sazby. *Politická ekonomie*. 2007, vol. LIV, no. 1, 3-22.
- Cottarelli, C. - Kourelis, A. 1994: Financial Structure, Bank Lending Rates, and the Transmission Mechanism of Monetary Policy [IMF Working Paper]. Washington: International Monetary Fund, March 1994.
- De Bondt, G. - Mojon, B. - Valla, N. 2005: Term Structure and the Sluggishness of Retail Bank Interest Rates in Euro Area Countries [Working Paper Series No. 518]. Frankfurt am Main: European Central Bank, 2005.
- English, W. B. 2002: Interest Rate Risk and Bank Net Interest Margins. *BIS Quarterly Review*. December 2002, 67-82.
- Flannery, M. J. 1981: Market Interest Rates and Commercial Bank Profitability: An Empirical Investigation. *The Journal of Finance*. 1981, vol. 36, no. 6, 1085-1101.
- Gambacorta, L. 2005: How Do Banks Set Interest Rates? [Temi di discussione No. 542]. Rome: Bank of Italy, February 2005.
- Hanweck, G. A. - Kilcollin, T. E. 1984: Bank Profitability and Interest Rate Risk. *Journal of Economics and Business*. 1984, vol. 34, no. 1, 77-84.
- Ho, T. S. - Saunders, A. 1981: The Determinants of Bank Interest Margin: Theory and Empirical Evidence. *The Journal of Financial and Quantitative Analysis*. 1981, vol. 16, no. 4, 581-600.
- Maudos, J. - Fernández De Guevara, J. 2004: Factors Explaining the Interest Margin in the Banking Sectors of the European Union. *Journal of Banking and Finance*. 2004, vol. 28, no. 5, 2259-2281.
- Mojon, B. 2000: Financial Structure and Interest Rate Channel of ECB Monetary Policy [ECB Working Paper Series No. 40]. Frankfurt am Main: European Central Bank, 2000.
- Sander, H. - Kleimeier, S. 2004: Convergence in Euro-zone Retail Banking? What Interest Rate Pass-through Tells Us about Monetary Policy Transmission, Competition and Integration. *Journal of International Money and Finance*. 2004, vol. 23, no. 2, 461-492.
- Saunders, A. - Schumacher, L. 2000: The Determinants of Bank Interest Margins: An International Study. *Journal of International Money and Finance*. 2000, vol. 19, no. 4, 813-832.
- Sorensen, C. K. - Werner, T. 2006: Bank Interest Rate Pass-Through in the Euro Area: A Cross Country Comparison [Working Paper Series No. 580]. Frankfurt am Main: European Central Bank, 2006.
- Weth, M. 2002: The Pass-through from Market Interest Rates to Bank Lending Rates [Discussion paper No. 11/02]. Frankfurt am Main: Deutsche Bundesbank, March 2002.